Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period: \_\_\_\_\_\_

**Energy Dynamics Dry Lab**

AP Biology, Ms OK, 2014-2015

**Background Information:**

Almost all life on this planet is powered, either directly or indirectly, by sunlight. Energy captured from sunlight drives the production of energy-rich organic compounds (i.e. the sugar glucose) during the process of photosynthesis. These organic compounds create biomass**.** The net amount of energy captured and stored by the producers in a system is the system’s net primary productivity. Gross primary productivity is a measure of the total energy captured**.**

In terrestrial (land) systems, plants play the role of producers. Plants use that biomass (organic compounds created during photosynthesis) to power their life processes or to store energy. Different plants have different strategies of energy use that reflect their role in various ecosystems. For example, annual weedy plants use a larger percentage of their biomass production for reproduction and seeds than do slower growing perennials. As plants, the producers are consumed or decomposed, and their stored chemical energy powers additional individuals, the primary consumers and other trophic levels of the biological community.

**Learning Objectives**

* To explain community/ecosystem energy dynamics, including energy flow, net primary productivity (NPP), and primary and secondary producers/consumers
* To demonstrate understanding of mathematical analyses in energy accounting and community modeling by calculating biomass and NPP, using data from a model system based on Brassica plants and butterfly larvae.

**Part I: Estimating Net Primary Productivity (NPP) of Fast Plants**

Primary productivity is a rate — energy captured by photosynthetic organisms in a given area per unit of time. Based on the second law of thermodynamics, when energy is converted from one form to another, some energy will be lost as heat. When light energy is converted to chemical energy (i.e. energy stored in the bonds of organic molecules like glucose) in photosynthesis or transferred from one organism (a plant or producer) to its consumer (e.g., an herbivorous insect), some energy will be lost as heat during each transfer.

In terrestrial ecosystems, productivity (or energy capture) is generally estimated by the change in biomass of plants produced over a specific time period. Measuring biomass or changes in biomass is relatively straightforward: simply mass the organism(s) on an appropriate scale and record the mass over various time intervals. The complicating factor is that a large percentage of the mass of a living organism is water — not the energy-rich organic compounds of biomass. Therefore, to determine the biomass at a particular point in time accurately, you must dry the organism. Obviously, this creates a problem if you wish to take multiple measurements on the same living organism. Another issue is that different organic compounds store different amounts of energy; in proteins and carbohydrates it is about 4 kcal/g dry weight and in fats it is 9 kcal/g of dry weight).

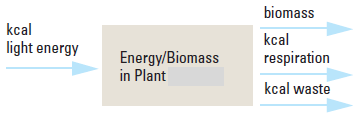
**A. Pre-Lab: Thinking through the processes**

1. Define the following terms:

* gross primary productivity
* net primary productivity
* secondary productivity

**B. Procedures: Using Sample Data to estimate NPP for Fast Plants**

The following diagram shows the energy flow into and out of a plant.



***Question:*** *What is another term for the “biomass” output arrow shown above?*

To determine the amount of light energy stored as biomass within plants (i.e. the net primary productivity), a team of students started 40 Wisconsin Fast Plants from seed. After growing them for 7 days under a regimen of 24 hours of light a day, the team randomly selected 10 plants. The plants were carefully pulled, with their roots. After washing the soil from the roots and blotting the plants, the team found the wet mass of all 10 plants.

Wet mass of 10 plants (Day 7) = 34.5g

The team then took the 10 plants and placed them in a drying oven at 200°C for 24 hours. They then found the dry mass of the 10 plants.

Dry mass of 10 plants (Day 7) = 7.6g

3. The team repeated the procedure above on Day 14 and Day 21. Use the data they obtained to fill in Data Table #1 by making all appropriate calculations.

Wet mass of 10 plants (Day 14) = 62.5g

Dry mass of 10 plants (Day 14) = 15.1g

Wet mass of 10 plants (Day 21) = 91.1g

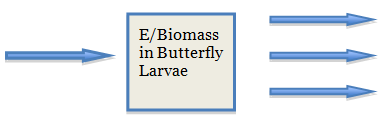
Dry mass of 10 plants (Day 21) = 25.3g

4. Complete the Data Table #2 for this exercise. Your team’s data will go in the empty column as “Team 1.” Find the Average NPP for each time period.

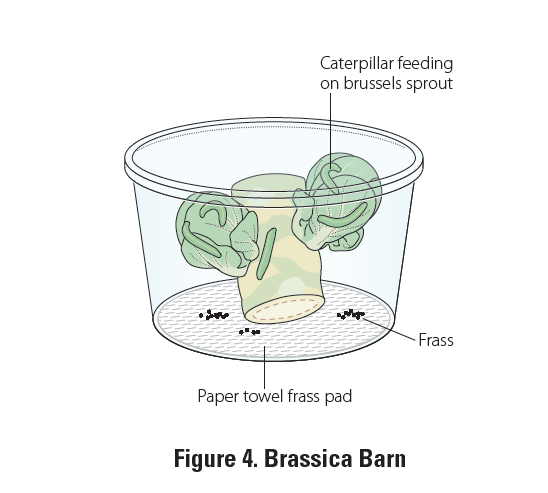
**C. Procedures: Using Sample Data to Estimate Energy Transfer from Producers to Primary Consumers**

In this part of the lab, teams used Brussels Sprouts as their producers and cabbage butterfly larvae as the primary consumers.

The following diagram shows energy flow into and out of a primary consumer (the larvae). The amount of biomass in the larvae represents the secondary productivity, the rate at which primary consumers convert the chemical energy in their food (plants) to their own chemical energy. Fill in the types of energy input and output on the diagram below (Hint: See the energy diagram in Part B).



***Question:*** *What is another term for the “biomass” output arrow you identified above?*



1. The team of students made a “brassica barn” by placing Brussels sprouts in an aerated container with 10 caterpillar larvae that were 12 days old. Before assembling the barn, students weighted both the sprouts and the larvae.

Wet mass of Brussels sprouts= 30g

Wet mass of 10 larvae = 0.3g

After 3 days, the team re-weighed the sprouts and larvae.

Wet mass of Brussels sprouts = 11g

Wet mass of 10 larvae = 1.8g

A drying oven was then used to find the biomass of the larvae, the remaining Brussels sprouts, and the frass.

Dry mass of Brussels sprouts = 2.2g

Dry mass of 10 larvae = 0.27g

Dry mass of frass from larvae = 0.5g

2. Complete the data tables for Part C using the information above.

**Data Tables:** **Energy Dynamics Dry Lab**

**Part B:**

***Data Table #1 (Just your team)***

Note: each gram of dry biomass is equivalent to 4.35 kcal of energy

Note: Please include UNITS for all columns and round values to the nearest hundredth (if applicable)!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Value** | **How will you calculate this value? + Helpful Tips** | **7 Day Plants** | **14 Day Plants** | **21 Day Plants** |
| Wet Mass for the 10 plants | Given, no calculation needed |  |  |  |
| Dry Mass for the 10 plants | Given, no calculation needed |  |  |  |
| Percent Biomass out of the Total Mass for the 10 Plants |  |  |  |  |
| Energy Content (NPP) for the 10 plants over\_\_\_\_\_ days | 4.35 kcal energy / 1 gram biomass |  |  |  |
| Energy content (NPP) per plant over \_\_\_\_\_ days |  |  |  |  |
| Energy content (NPP) per day per plant |  |  |  |  |

***Data Table #2 (Class data)***

Note: For Team 1, fill in the NPP per day per plant values you calculated in the previous data table.

Note: Please include UNITS for the last column.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time (days)** | **Team 1** | **Team 2** | **Team 3** | **Team 4** | **Team 5** | **Team 6** | **Class Mean** |
| 7 |  | 0.43 | 0.47 | 0.44 | 0.46 | 0.44 |  |
| 14 |  | 0.49 | 0.51 | 0.50 | 0.49 | 0.52 |  |
| 21 |  | 0.55 | 0.54 | 0.55 | 0.53 | 0.51 |  |

**Part C:**

Known values (energy contained):

plant 4.35 kcal/g larvae 5.5 kcal/g frass (i.e. larvae “poop”) 4.75 kcal/g

Note: Please include units for all values entered into the charts below.

***Data Table #3 (Energy in Brussel Sprouts)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Value** | **How will you calculate these values? + Helpful Tips** | **Day 1** | **Day 3** | **Change from Day 1 to Day 3** |
| Wet mass of Brussels sprouts (in grams) | Values given for Day 1 and Day 3  How can we calculate the change in wet mass from Day 1 to Day 3? |  |  |  |
| Plant % Biomass (calculate for Day 3) | You will need to use the given values for wet mass on day 3  How can we calculate the % biomass on Day 3? | Same as day 3 |  | N/A |
| Plant energy (NPP) (in kcal) | Given calculation: Wet mass x % biomass x 4.35 kcal  How can we calculate the change in plant energy from Day 1 to Day 3 (i.e., the kcals consumed per 10 larvae)? |  |  | (Note: This represents the kcals consumed per 10 larvae) |
| Plant energy consumed per larvae (in kcal) | How can we calculate the plant energy consumed per larvae from Day 1 to Day 3? | N/A | N/A |  |

***Data Table #4 (Energy in Butterfly Larvae)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Value** | **How will you calculate these values? + Helpful Tips** | **Day 1** | **Day 3** | **Change from Day 1 to Day 3** |
| Wet mass of 10 larvae (in grams) | Values given for Day 1 and Day 3  How can we calculate the change in wet mass from Day 1 to Day 3? |  |  | (Note: This represents the grams gained by the larvae) |
| Wet mass per larvae (in grams) | How can we calculate the wet mass per larvae?  How can we calculate the change in wet mass per larvae from Day 1 to Day 3? |  |  | (Note: This represents the grams gained per larvae) |
| Larvae % biomass | You will need to use the given values for wet mass on day 3  How can we calculate the % biomass on Day 3? | Same as day 3 |  | N/A |
| Larvae Energy Production (in kcal) | Given calculation: Wet mass x % biomass x 5.5 kcal  How can we calculate the change in larvae energy from Day 1 to Day 3 (i.e., the kcals produced per 10 larvae)? |  |  | (Note: This represents the kcals produced per 10 larvae) |
| Change in Larvae Energy Production Per Individual | How can we calculate the change in energy produced per larvae from Day 1 to Day 3? | N/A | N/A |  |

***Data Table #4 (Energy in Frass)***

|  |  |  |
| --- | --- | --- |
| **Value** | **How will you calculate these values? + Helpful Tips** | **Day 3** |
| Dry mass of frass from 10 larvae (in grams) | Value Given |  |
| Frass energy (in kcal) | Given calculation: frass dry mass x 4.75 |  |
| Energy of frass from 1 larvae? (in kcal) | How can we calculate the energy of frass from one larvae? |  |

**Summary Question:** How much of the total energy consumed by EACH larvae was lost to respiration?

How can we calculate this value?

**Discussion / Conclusion:**

In your discussion /conclusion paragraph, include the following information.

1)

a. State the class calculated mean NPP values per plant per day for the 7, 14, and 21 day plants. Which value is highest? (2 points)

b. Explain why you see this trend. (2 points)

2)

a. Which value in your data tables from Part C represents the secondary production (per individual)? (1 point)

b. Justify your choice based on the definition for secondary production. (2 points)

3)

a. What value did you calculate for the energy lost to respiration for each larvae? (1 point)

b. Explain the calculation you performed to determine this value. (2 points)

**Rubric:**

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Letter** | **Points Received** | **Comments** |
| 1 | A | /2 |  |
| B | /2 |  |
| 2 | A | /1 |  |
| B | /2 |  |
| 3 | A | /1 |  |
| B | /2 |  |